National Aeronautics and Space Administration

Partnership Produces Record-Setting Power, Reliability, and Efficiency in a Low Mass, Free-Piston Stirling Convertor

Technology developed through a series of Small Business Innovation Research (SBIR) contracts with Ohio-based Sunpower, Inc. in partnership with NASA's Glenn Research Center has resulted in the Advanced Stirling Convertor (ASC), an 80 watt free-piston Stirling power convertor that produces electric power from any source of heat. The ASC can be used in any application that requires conversion of heat into electric power with high efficiency and low mass. The ASC provides a state-of-the-art power conversion system for potential future NASA deep space and planetary missions enabled or significantly enhanced by the application of radioisotope power systems. Other terrestrial applications being considered are a liquid-fueled soldier-carried portable power system and an efficient portable solar-to-electric convertor.

Benefits of Technology Transfer

- The high efficiency will offer a 4-fold reduction in fuel or radioisotope material usage, reducing costs.
- The high specific power is 2 times that of existing convertors.
- Smaller size and lower mass will provide more options for physical location of the spacecraft power system, allow room for larger payloads, and in terrestrial applications enable portable and soldier-wearable power systems.
- System reliability and product life are high due to non-contacting moving parts, which eliminates inherent wear-out mechanisms.

success

On the Record

"The Stirling Convertor technology developed by Sunpower, with origins in the SBIR Program, has proved to be a highly efficient, low mass convertor that can increase system reliability and product life."
— Jeffrey Schreiber, Team Lead for Stirling at NASA's Glenn Research Center

"This project has been both highly successful and fun. The SBIR Program is well structured and allowed us to make ground-breaking advancements in performance and specific power. During Phase I we performed extensive computer optimization studies. Additional SBIR phases allowed us to demonstrate these advancements in hardware." *— J. Gary Wood, Engine Technical Leader, Sunpower, Inc.*

About Sunpower

Sunpower is a recognized world leader in state-of-the-art, highly efficient, low mass, reliable Stirling machines. For more than 35 years, Sunpower, the originator of free-piston Stirling engines, has developed and delivered fully engineered engine prototypes and preproduction units for a variety of applications in aerospace, military, household appliance, and research industries.

Technology Origins

The ASC consists of a free-piston Stirling engine and an integral linear alternator that converts the piston reciprocating motion to electrical output. Weighing just 1.3 kg, the lightbulb-sized ASC has evolved to demonstrate 38 percent conversion efficiency, extended operation, and a 2-fold improvement in specific power over competing power sources. The higher efficiency reduces the amount of radioisotope material or fuel required by a factor of 4 or more, decreasing costs. Key technologies that enable high efficiency and low mass are hydrostatic gas bearings, moving-magnet linear alternators, high-frequency operation, high-temperature hot end materials and fabrication processes, and high-temperature, high-porosity regenerators. The ASC is similar in design configuration and size to thousands of commercial terrestrial Sunpower cryocoolers. The company has produced five generations of ASC-related hardware, evolving the technology progressively with each build. Advanced Stirling Convertors have been running continuously in Glenn's test facilities to demonstrate their ability to be used in generators. Glenn has contributed its expertise in reliability testing, materials assessment, and risk reduction, and has provided access to unique facilities that have allowed for more than 165,000 hours of testing and operation on ASC research and experimental models as well as the prototypes for flight.

The Transfer Process

ASC development, funded by the SBIR program, began in 2001 as one of 10 competitively awarded contracts intended to address the power conversion needs of future radioisotope power systems. The convertor efficiency and low mass objectives were met early in Phase 1 with continued technology refinement and improvement in Phases 2 and 3. These successes led to NASA's decisions to accelerate development by increasing technical support from Glenn and subsequently integrating the ASC in 2007 as a critical component of the Advanced Stirling Radioisotope Generator (ASRG) being developed by Lockheed Martin Space Systems Company for the Department of Energy. Dual opposed convertors are used in the ASRG to achieve balanced operation, and its use in the ASRG has led to more than a 2-fold increase in specific power when compared with radioisotope thermoelectric generators used in prior missions.

Gearing Up for Commercialization

The ASC's small physical size, high conversion efficiency, capability for long-life operation, and high specific power make it a candidate for future deep space missions and military portable power systems. Potential space missions include providing electric power for deep space missions, surface rovers, and stationary power generators.

For More Information

If you would like additional information about Glenn's technology transfer opportunities, please contact:

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